Volatility and causality study of the daily returns on the Bucharest Stock Exchange during 2007-2011

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Abstract

International capital markets tend to be characterized by volatility, which is always a function of world economic and political environment and is frequently associated with contagion risk and increased cross-market linkages. This phenomenon affects both developed markets and emerging markets, and, being integrated in the context of international financial markets through the globalization process, Romanian capital market could not avoid external influencing factors multiplied by economic recession. We have analyzed the influence of the international capital markets on the evolution of Bucharest Stock Exchange during 2007-2011 in two separate periods (during the 2007-2009 crisis and after the crisis), using correlation analysis and Granger causality tests on daily data. Our main interest was to see if and how the behavior of the Bucharest Stock Exchange was different during the crisis and after the crisis and how the volatility of the Romanian market changed in the post crisis period. Our results confirmed the high degree of interconnection between financial markets acknowledged by the general theory, showing that there was a high degree of correlation between the Romanian stock market and international markets during the 2007-2009, correlation which decreases slightly in the succeeding period. Another inference was that during the whole 2007-2011 period there was a clear one-way causality induced from the international capital markets towards Bucharest Stock Exchange.

Key words: data mining, Granger, correlation, crisis, stock markets, volatility

JEL classification: G01, G14, G15

1. Introduction

In the past decades, the interrelationships among the world's stock markets have increased dramatically, so the concept of "independent stock markets" might seem utopic.
This closed linkage between stock markets has been subject of a voluminous empirical literature concerned with analyzing the causes and effects of this type of economic interdependence.
According to the specialized studies on this subject, there are four main reasons for the interrelationships in stock markets fluctuations. In the first place, interdependences may occur where there is a high degree of integration between economies as a whole, such as within the European Union, and especially given the introduction of the single currency. In this case, the strong interrelationship that exists between the stock regional markets represent a logical consequence of the substantial trade and investment linkages, common institutional and regulatory structures and shared macroeconomic conditions.
A second situation that generates this type of interrelationships may arise from country-specific shocks that are rapidly transmitted to other markets. In general, markets that are larger in size and more dominant tend to influence smaller or less important markets. This transmission can occur through the international capital market provoking a reaction in domestic capital markets (known as market contagion).
The third source of stock markets linkage derives from shared investor groups. More specific, when two countries are geographically proximate and have similar groups of investors in their markets, between these markets there is a mutual influence.
Finally, another cause that generates stock markets interrelationships arises from shocks specific to sectors of each economy. For example, if a technology shock affects a particular sector, stock price interrelationships may arise from connections between this and other sectors within a market.
Despite the impressive numbers of studies and articles dealing with the correlations of the world's stock markets are available, articles focusing solely on a specific small market (as the Romanian one) and its relationship with

other international markets (which are very different from a global economic and financial perspective) are virtually non-existent.
In fact, when European stock markets are examined in a broader multilateral context, in conjunction with Asian or North American capital markets, an emphasis is usually placed upon the larger economies. For example, Darbar and Deb (1997) included only the U.K. in their study of international capital market integration, Francis and Leachman (1998) added Germany, Arshanapalli and Doukas (1993) excluded Germany and focused on France and the U.K., Cheung and Lai (1999) removed the U.K. and added Italy to France and Germany.
In our study, we want to surpass this omission of the specific literature and to focus on the interrelationship between the Romanian stock market and three foreign very different markets: New York Stock Exchange, Frankfurt Stock Exchange and Warsaw Stock Exchange).
Since one of the most important problems in the modern finance is finding efficient ways of summarizing and visualizing the stock market data that would allow one to obtain useful information about the behavior and correlations of differents markets and since the amount of data generated by the stock market every day is enormous, we have used data mining and statistical techniques in order to collect, correct and analyze data from the compared stock markets mentioned above. We have first applied logistic regression and calculated basic statistical correlation indicators and then we have introduced the Granger causality test (Granger, 1969) to check the short run relationship between selected variables (in our case, the five selected stock indices).
The paper itself is divided into five main areas. Section two contains the literature review and summaries previous studies in this area. Section three provides details regarding data description and explains the methodology. The results are dealt with in Section four. The paper ends with some brief concluding remarks in Section five.

2. Literature review

Over time, many investment managers and academics were interested to study the correlations and causalities between major and emerging stock market indices. Also, from obvious practical reason, the reactions of the stock markets on many types of previous financial and economic crisis were examined in detail by the research and academic community. More recently, starting with 2008, many authors showed interest to study the correlations between various stock markets during the 2007-2009 financial crisis.
King M.A. and Wadhwani S. (1990) investigated why, in October 1987, almost all stock markets fell together despite widely differing economic circumstances and argue that contagion between markets occurs as the result of attempts by rational agents to infer information from price changes over other markets. The two authors have the opinion that contagion provides a channel through which a “mistake” in one market can be transmitted to other markets. They find that hourly stock price data from New York, Tokyo and London during an eight month period around the crash offer support for the contagion model. In addition, the two authors find that the magnitude of the contagion coefficients is increasing with volatility.
Almost at the same period, Lee and Kim (1993) studied the effect of the same event across 12 major stock markets. Also, Calvo and Reinhart (1996) analyzed the impact of the Mexican peso crisis in 1994 on contagion in major financial markets.
Bekaert G. and Harvey C.R. (1997) analyzed the reasons that volatility is different across emerging markets, particularly with respect to the timing of capital market reforms. They argue that capital market liberalizations often increase the correlation between local market returns and the world market, but do not drive up local market volatility.
Choe H., Kho B.C., Stulz R.M. examined the impact of foreign investors on stock returns in Korea from November 30, 1996 to the end of 1997 using order and trade data and found strong evidence of positive feedback trading and herding by foreign investors before the period of Korea's economic crisis. The authors argued that during the crisis period, herding falls, and positive feedback trading by foreign investors mostly disappears. The conclusion of their research is that there is no evidence that trades by foreign investors had a destabilizing effect on Korea's stock market over the sample period. In particular, they found that the market adjusted quickly and efficiently to large sales by foreign investors, and these sales were not followed by negative abnormal returns.
Aggarwal R., Inclan C. and Leal R. (1999) examined the kinds of events that caused large shifts in the volatility of emerging stock markets during the period 1985 - 1995. They found that most events tend to be local and include the Mexican peso crisis, periods of hyperinflation in Latin America, the Marcos-Aquino conflict in the Philippines, and the stock market scandal in India. According to the authors, the October 1987 crash is the only global event during the period 1985-1995 that caused a significant jump in the volatility of several emerging stock markets.
Gelos R.G. and Sahay R. (2001) examined financial market co-movements across European transition economies and compared their experience to that of other regions. They found that correlations in monthly indices of exchange market pressures can partly be explained by direct trade linkages, but not by measures of other fundamentals.

Forbes K.J. and Rigobon R. (2002) argue that there is a high level of market co-movement during all periods, which they call "interdependence". Previous research suggested that contagion (defined as a significant increase in market co-movement after a shock to one country) it is often occurring during crises. Forbes and Rigobon's paper is in opposition with that belief and shows that there was virtually no increase in unconditional correlation coeficients (i.e., no contagion) during the 1997 Asia crisis, 1994 Mexican devaluation and 1987 U.S. market crash.

Maroney N., Naka A. and Wansi T. explored risk and return relations in six Asian equity markets affected by the 1997 Asian financial crisis and found that after the start of the crisis, national equity betas increased (due to leverage linked to exchange rates) and average returns fell substantially. Subsequently, the authors propose a new probability-based asset pricing model that captures leverage effects using valuation ratios. Their results show the role of leverage in explaining the likelihood of the financial crises.

Hartmann P., Straetmans S. and de Vries C.G. (2004) characterize asset return linkages during periods of stress by an extremal dependence measure. Their estimates for the G-5 countries suggest that simultaneous crashes between stock markets are much more likely than between bond markets. Also, their data show that stock-bond contagion is approximately as frequent as flight to quality from stocks into bonds. Also, they found that extreme cross-border linkages are surprisingly similar to national linkages, illustrating a potential downside to international financial integration.

Latter, Bekaert G., Harvey C.R. and Ng A. (2005) study contagion and propose a two-factor model with time-varying betas that accommodates various degrees of market integration. The authors apply this model to stock returns in three different regions: Europe, Southeast Asia, and Latin America. In addition to examining contagion during crisis periods, they document time variation in world and regional market integration and measure the proportion of volatility driven by global, regional, and local factors.

Markwat T., Kole E. and van Dijk D. (2009) show that stock market contagion occurs as a domino effect, where confined local crashes evolve into more widespread crashes. Using a novel framework based on ordered logit regressions the authors model the occurrence of local, regional and global crashes as a function of their past occurrences and financial variables. They find significant evidence that global crashes do not occur abruptly but are preceded by local and regional crashes.

Over time, Romanian authors were also interested to study the specific behavior of Romanian exchange traded stocks in relation with other markets but also at different stages of the economic cycle. Lupu R., Tudor C. (2008) investigated the possibility to provide a forecast for the sign of asset returns at Bucharest Stock Exchange taking into account eight stocks part of BET index and using an EGARCH model. They find that some of the coefficients of model were statistically significant meaning that there is some power that the second and the third moments of the distribution have some power to forecast the sign of the future returns.

Pop C., Curutiu C. and Dumbrava P. (2009) present the Bucharest Stock Exchange evolution before the 2007-2009 crisis started to manifest and try to identify the main factors which influenced its explosive growth. The paper investigates the current financial crisis influences on Bucharest Stock Exchange – with an emphasis over the factors which might have deepen the descendent trend for the Romanian stock exchange market. The authors also present the effects of the current financial crisis on the future development of Bucharest Stock Exchange, taking into consideration the position of the Romanian capital market in Eastern Europe.

Harrison B., Lupu R., and Lupu I. (2010) studied the statistical properties of the CEE stock market dynamics using a panel data analysis and found that there is evidence of stationarity for the returns provided by the Romanian stock indices. They have also identified some particular characteristics of returns in these markets such as a great amount of non-linearity and cross correlation.

Tudor C. (2010) investigated the contemporaneous correlations and causal relationships among six Central and Eastern European stock markets and the USA stock exchange, paying special consideration to the effects of the 2007-2009 global financial crisis. She reveals that the relationships among CEE stock markets are time varying. She found that, before the crisis, stock market linkages are limited but stock markets in the CEE region have became increasingly integrated during the crisis, confirming previous findings and reflecting this geographical area's increased importance in the European and in the world economy.

3. Data and methodology

In order to investigate the correlation between Romanian stock market and other relevant major and emerging exchanges, we have collected daily data for two Romanian stock indices (BET and BET-FI computed by Bucharest Stock Exchange) and three foreign indices (S&P500 for the New York Stock Exchange, DAX for the Frankfurt Stock Exchange and WIG20 for Warsaw Stock Exchange). Also we used in our analysis daily data for two Romanian companies listed on Bucharest Stock Exchange (Petrom and BRD-GSG) and one foreign company (Erste Bank) listed on Vienna Stock Exchange. The data for the Romanian indices was collected from Bucharest Stock Exchange web site (www.bvb.ro) and the data for the foreign indices and stocks was collected from Yahoo Finance (finance.yahoo.com). For the period January 1st 2007 – May 6th 2011 the result was 8 sets

of 1091 observations containing the daily closing prices for those 5 indices and 3 companies. We were very carefull to exclude from the initial date all the situations when some of the stock exchanges were closed for local holidays while on the other the trading was open. All the data was then transformed into daily returns by applying the first difference. Subsequently, we studied the correlations between the 5 indices and the linear regression relation between S&P500 returns and each of the remaining 4 indices and 3 companies' returns (using least squares method). Also, we used Granger tests in order to find if there is causality and not just "meaningless correlations" between major markets and Bucharest Stock Echange.

The concept of cointegration was developed by Engle and Granger (1987). Cointegration indicates long run relationship between two variables. Most financial data are non-stationary and are related to the same influences which make them timely interdependent.

Engle and Granger proved that the regression result of two I(1) variables might not be spurious if these two variables are cointegrated. If yt and xt are two I(1) variables, a combination of yt and xt, such as $yt - \beta xt$, is also I(1) for any number β. However there may be a case in which $\beta \neq 0$ and $yt - \beta xt$ is I(0) rather than I(1). In such a case, there is a constant mean, variance and the time distance between any two variables in the series is the only basis of autocorrelation. If there exists a β that makes the above case hold, then we say that series yt and xt are cointegrated and β is cointegrating parameter. In this case, the result of regression of yt on xt is not spurious.

More specific, the Granger causality test checks whether variable Y's current value can be explained by its own past value and whether the explanatory power could be improved by adding the past value of another variable X. If the coefficient of X is statistically significant, X is said to Granger cause Y. The model for Granger causality test is as following:

$$Yt = \alpha 0 + \Sigma \alpha k Yt\text{-}k + \Sigma \beta t Xt\text{-}k + u \quad (1)$$

$$Xt = \varphi 0 + \Sigma \varphi k Xt\text{-}k + \Sigma \omega t Yt\text{-}k + v \quad (2),$$

where α, β, φ and ω are the coefficients of X and Y, u and v are residuals with the mean equals to zero and $\sigma^2 < \infty$.

The null hypothesis that Yt doesn't Granger-cause Xt is rejected if ωt's, $k>0$ in equation (1) are jointly significantly different from zero by using F-test.

The null hypothesis that Xt doesn't Granger-causeYt is rejected if βt's, $k>0$ in equation (2) are jointly significantly different from zero by using the F-test.

If both βt's, $k>0$ and ωt's, $k>0$ are jointly significantly different from zero, then there is bi-directional causality between X and Y.

In our study, we use the first difference of log of stock market variables (or in other words the stock's return) to perform Granger causality tests.

4. Results and interpretations

The analysis of the daily observation for the two Romanian stock indices and three international indices (BET, BET-FI, WIG20, DAX and S&P500) shows that we can not assume a normal distribution of daily returns for any of the 5 samples (see Table 1). We can immediately observe that the volatility and the maximum negative amplitude of weekly variations are much higher for the Romanian indices in comparison with the international mature and emerging stock indices.

Studying the matrix of cross correlations inside the sample, we see a high correlation between the Romanian indices and mature market indices (DAX and S&P500) but not higher than the correlations between WIG20 and the same two mature market indices (Table 2).

The study of the linear dependence between every two indices shows that we have a high degree of confidence when saying that the Romanian stock indices are moving in sync with the international indices because the statistical tests show that the linear regression coefficient is in every case significantly different from zero. Still, in every case we obtain a relatively low R squared which tells us that there are also other important factors that contribute to the evolution of the daily returns of the Romanian stock indices during the period 2007-2009 (see Table 3).

Table 1

Daily data statistics (whole 2007-2011 sample)

	SP500	DAX	WIG20	BET	BET_FI	BRD	SNP	EBS
Mean	9.08E-05	0.000238	2.62E-05	-0.000118	-0.000428	0.000134	9.58E-05	0.000172
Maximum	0.115800	0.114782	0.084966	0.111427	0.148269	0.150000	0.147287	0.185604

Minimum	-0.090350	-0.071639	-0.080962	**-0.122929**	**-0.148500**	-0.146597	-0.149606	-0.181287
Std. Dev.	0.016836	0.016420	0.018272	**0.021420**	**0.031117**	0.028662	0.028684	0.037509
Skewness	0.086321	0.548427	-4.51E-05	-0.274302	0.114183	-0.058182	0.045699	0.174561
Kurtosis	10.71095	10.92862	5.444910	7.795422	7.496295	7.884436	8.253445	7.318146
Jarque-Bera	2704.251	2912.338	271.7311	1059.044	921.3867	1085.147	1254.970	853.1742
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Source of data: Bucharest Stock Exchange and Yahoo Finance; calculations by the authors

Table 2

Correlations (daily sample)

	SP500	DAX	WIG20	BET	BET_FI	BRD	SNP	EBS
SP500	1.000000	0.620938	0.401079	**0.246520**	**0.293600**	0.237712	0.216438	0.391003
DAX	0.620938	1.000000	0.625859	**0.391125**	**0.488257**	0.417375	0.391027	0.618311
WIG20	0.401079	0.625859	1.000000	0.392674	0.464207	0.380245	0.394600	0.537949
BET	0.246520	0.391125	0.392674	1.000000	0.658603	0.679020	0.651422	0.388524
BET_FI	0.293600	0.488257	0.464207	0.658603	1.000000	0.714601	0.626567	0.453313
BRD	0.237712	0.417375	0.380245	0.679020	0.714601	1.000000	0.604064	0.443381
SNP	0.216438	0.391027	0.394600	0.651422	0.626567	0.604064	1.000000	0.365926
EBS	0.391003	0.618311	0.537949	0.388524	0.453313	0.443381	0.365926	1.000000

Source of data: Bucharest Stock Exchange and Yahoo Finance; calculations by the authors

Table 3

Linear regression output (daily sample)

	DAX	WIG20	BET	BET_FI	SNP	BRD	EBS
S&P500 coefficient	0.605587	0.435292	0.313632	0.542638	0.368747	0.404684	0.871112
Std. Error	0.023166	0.030127	0.037363	0.053538	0.050404	0.05011	0.062137
t-Statistic	26.14111	14.44866	8.394235	10.1355	7.315862	8.075995	14.01917
Prob.	0	0	0	0	0	0	0
R-Squared	0.385564	0.160864	0.060772	0.086201	0.046845	0.056507	0.152883

Source of data: Bucharest Stock Exchange and Yahoo Finance; calculations by the authors

In order to see if the correlations between major stock markets and Bucharest Stock Exchange is not only a mere coincidence, we rand several Granger causality tests between S&P500 New York Stock Exchange index and all the other indices and stocks included in our research. In our causality tests we have used 1-5 lags because from our empirical observations of the market behavior we have previously concluded that market shocks are very fast transmitted from one stock exchange towards the others and their influence on specific daily market behavior is no older than one week. Table 4 shows that Granger causality tests gives us arguments to say that SP500 is at least in part causing the daily returns of all other major and emerging markets that we have investigated. At the same time, results shown in Table 4 argue that we don't have a basis to say that the other stock markets included in our research (Romanian, Poland and Germany) are significantly causing the daily returns of the American stock market.

Table 4

Results of Granger causality tests (daily sample)

Pairwise Granger Causality Tests
Lags: 5

Null Hypothesis:	Obs	F-Statistic	Probability
DAX does not Granger Cause SP500	1086	2.94044	0.01210
SP500 does not Granger Cause DAX		21.2090	**2.8E-20**
WIG20 does not Granger Cause SP500	1086	1.54891	0.17190

SP500 does not Granger Cause WIG20		14.0762	**2.3E-13**
BET does not Granger Cause SP500	1086	1.46290	0.19927
SP500 does not Granger Cause BET		28.8677	**1.5E-27**
BET_FI does not Granger Cause SP500	1086	1.37265	0.23196
SP500 does not Granger Cause BET_FI		22.4189	**2.0E-21**
BRD does not Granger Cause SP500	1086	2.00141	0.07596
SP500 does not Granger Cause BRD		19.2386	**2.3E-18**
SNP does not Granger Cause SP500	1086	1.10090	0.35815
SP500 does not Granger Cause SNP		24.9090	**8.3E-24**
EBS does not Granger Cause SP500	1086	1.93242	0.08635
SP500 does not Granger Cause EBS		17.6883	**7.1E-17**

Source of data: Bucharest Stock Exchange and Yahoo Finance; calculations by the authors

5. Conclusions

Our data shows that for the period January 2007 – April 2011 the daily returns of the five stock market indices studied (S&P500, DAX, WIG20, BET and BET-FI) do not have a normal distribution.

We found that the Romanian capital market had the highest volatility inside the sample, both for the whole period but also on stages (during the crisis and after the crisis). Also we found a slight decrease in volatility for the Romanian stock market after the crisis (see table 5). The same conclusion is valid for all the other 3 market indices included in our study.

Table 5

Romanian stock market's volatility during and after the crisis

	SP500	DAX	WIG20	BET	BET_FI
Std. Dev. (whole period)	0.016836	0.016420	0.018272	**0.021420**	**0.031117**
Std. Dev. (Jan. 2007 – Feb. 2009)	0.020161	0.018728	0.020397	**0.022886**	**0.032238**
Std. Dev. (Mar 2009 – Apr 2011)	0.012709	0.013733	0.015814	**0.019627**	**0.029722**

Source of data: Bucharest Stock Exchange and Yahoo Finance; calculations by the authors

At the same time we found that the correlation between the Romanian stock market and the major markets (represented in our study by S&P500 and DAX indices) was higher during the financial market crisis (2007-2008) and slightly decreased during the after crisis period (2009 – 2011). Table 6 shows that both the BET and BET-FI indices and the two Romanian stocks BRD and SNP had a lower correlation with S&P500 during the after crisis period in comparison with the 2007-2009 period.

Table 6

Romanian stock market's correlation with S&P500 during and after the crisis

	BET	BET_FI	BRD	SNP
Correlation with S&P500 (whole period)	0.246520	0.293600	0.237712	0.216438
Correlation with S&P500 (Jan. 2007 – Feb. 2009)	0.25788	0.349132	0.280902	0.245233
Correlation with S&P500 (Mar 2009 – Apr 2011)	0.236295	0.261609	0.211018	0.196796

Source of data: Bucharest Stock Exchange and Yahoo Finance; calculations by the authors

Also, the Granger causality tests (with 1-5 lags) that we have performed on the data sample for the whole 2007-2011 period gives shows that we have arguments to say that the daily returns of the Romanian stock market during that period was in part caused by the evolution of the S&P500 index and other major international stock markets. We found that a similar conclusion is valid for another European emerging stock market, the Polish stock market (represented in our study by the WIG20 index).

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